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ABSTRACT

A survey of grade 7, 8 and 9 science teachers in New Brunswick and Nova Scotia was conducted as part of a research program to determine the consequences for teaching and learning of the recent introduction of the SciencePlus program developed by the Atlantic Science Curriculum Project and the need for further curriculum and professional development. The survey explored some of the conditions of teaching, teachers' goals and instructional practices, and teachers' professional development needs and preferences. Comparison with previously published research indicated that teaching practices in the region appear to have changed over the past decade in the direction of greater hands-on practical activity. This report combines data from the New Brunswick and Nova Scotia surveys to look at the association between selected teaching conditions and selected teaching practices. Chi-square statistical analyses have been done to establish the existence of statistically significant associations between these sets of categories. (KR)

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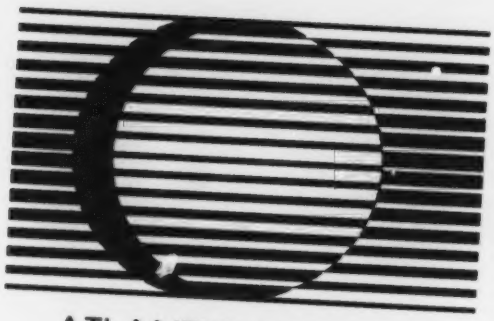

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CONDITIONS THAT MAY AFFECT SCIENCE TEACHING IN GRADES 7, 8, AND 9

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ASSOCIATION OF SELECTED TEACHING CONDITIONS WITH REPORTED INSTRUCTIONAL PRACTICES:

From a survey of New Brunswick and Nova Scotia Grade 7, 8 and 9 Science Teachers

Research Report Number 4
Atlantic Science Curriculum Project

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ASSOCIATION OF SELECTED TEACHING CONDITIONS WITH REPORTED INSTRUCTIONAL PRACTICES: From a survey of New Brunswick and Nova Scotia grade 7, 8 and 9 science teachers

Summary: The frequency of hands-on practical activities and the relative emphasis teachers give to testing for understanding have each been found to be associated with selected teaching conditions. The most significant association found, both statistically and practically, is with the use of the **SciencePlus** program (Atlantic Science Curriculum Project, 1986-90). Other teaching conditions which appear to favour hands-on science and an assessment emphasis on understanding as opposed to simple recall of knowledge include the teacher's participation in professional development activities, the location of teaching in a lab-classroom or laboratory rather than a regular classroom, a teaching assignment which includes mainly science teaching and the teacher's formal education in science. On the other hand, neither the number of subjects a teacher has to prepare to teach each week nor the average class size appear to be associated to a statistically significant extent with frequency of hands-on activity or relative emphasis on testing for understanding.

Introduction

A survey of grade 7, 8 and 9 science teachers was conducted in both New Brunswick and Nova Scotia during May, 1990 as part of a research program to determine (1) the consequences for teaching and learning of the recent introduction of the **SciencePlus** program (ASCP, 1986-1990) and (2) the need for further curriculum and professional development. The survey explored some of the conditions of teaching, teachers' goals and instructional practices and their professional development needs and preferences. Separate reports based on frequency and percentage of responses were produced for New Brunswick and Nova Scotia (McFadden, 1990a, 1990b). Comparison with previously published research (Hacker et al, 1978; McFadden, 1980) indicated that teaching practices in the region appear to have changed over the past decade in the direction of greater hands-on practical activity. Moreover, student assessment practices of New Brunswick and Nova Scotia junior high science teachers appear to place more emphasis on opportunities for students to express their understanding in their own words than do the reported assessment practices of junior high science teachers in Ohio (Fleming and Chambers, 1983) and British Columbia (Bateson, 1990) and of Canadian secondary teachers generally (Wilson, 1990).

This report combines data from both New Brunswick and Nova Scotia to look at the association between selected teaching conditions and selected teaching practices. A cross tabulation has been done between categories of response to questions about selected teaching conditions and categories of response to questions about selected teaching practices. Chi-square statistical analyses have been done to establish the existence of

statistically significant associations between these sets of categories. Such associations can be the basis for reasonable conjecture about causal relations and even decisions to take practical action that might improve instruction. However, it should be emphasized, a statistically significant association of this sort does not by itself establish causal links nor explain the relationship that has been found. Likewise, the absence of a statistically significant association does not mean that a practically important association does not exist; a larger number of responses to the survey or better questions might have revealed such an association.

SciencePlus and Instructional Practices

In the survey questionnaire, grade 7, 8 and 9 science teachers in New Brunswick and Nova Scotia were asked "How many years have you been using the textbook program, **SciencePlus** (at any grade level)?" and instructed: "If you participated in the field tests or pilot trials, please include these years)."

Field-testing of early draft materials began in a few schools as early as 1980, so that 7 of 492 respondents were able to claim that "This is the ninth or greater year I have used it", including 6 teachers from Nova Scotia. However, 447 of the respondents (90.9%) could claim no more than 4 years of experience using the program (including 18.1% who had never used it and 35.0% who were completing their first year using the program). Of the 45 teachers who have used the program for more than four years (i.e. who also taught using field test materials prior to 1986), 8 are New Brunswick teachers, the remainder Nova Scotians.

The grade 7 materials were published in the summer of 1986 and introduced that Fall into many Nova Scotia classrooms, followed in successive years by the grade 8 and 9 materials. In May 1990 only 8 of 282 Nova Scotia survey respondents reported no experience using the **SciencePlus** program, indicating that **SciencePlus** is now the program of choice of nearly all of the schools in that province.

In New Brunswick the provincial Department of Education selects a single program for all schools. After three years of testing several programs, New Brunswick introduced **SciencePlus** in all grade 9 classrooms in the Fall of 1989, with implementation in grades 7 and 8 to follow over the next two years. As a result, 81 of 210 New Brunswick respondents could report in May 1990 that they had never used the **SciencePlus** program, providing a comparison group to those using **SciencePlus**.

Table 1. Association of the use of SciencePlus with the conduct of hands-on practical activities

Average frequency of hands-on activities	Experience using the SciencePlus program					
	Never used	1st Year	2nd/3rd Year	4th + Year	Total row N	%
Twice monthly or less	76.4	44.8	50.7	34.0	246	50.0
Once per week	15.7	26.2	25.4	27.8	120	24.4
Twice per week	5.6	19.2	14.9	22.7	80	16.3
More than twice per week	2.2	9.9	9.0	15.5	46	9.3
Total column N	89	172	134	97	492	
%	18.1	35.0	27.2	19.7		100.0

The chi-square statistic is 40.26926. The probability that this kind of distribution of responses might occur by chance is less than one in 10,000 (P = .0000).

Comments. Another, perhaps simpler way of representing the data in Table 1 is to observe that 56% of respondents using **SciencePlus** report conducting on average at least one practical activity per week with their classes, whereas only 24% of those not using **SciencePlus** report doing so.

These differences in the frequency of conduct of practical activities do not appear to be a consequence of differences in the characteristics of the two groups of teachers. Eighty one of the eighty nine non-users of **SciencePlus** are New Brunswick grade 7 and 8 teachers. Differences in average teaching practices between Nova Scotia and New Brunswick teachers can be fully accounted for by the large group of New Brunswick teachers who had not at the time of the survey yet used **SciencePlus**. On the other hand, Nova Scotia and New Brunswick teachers do not differ in any of the other ways found in this study to be associated with differences in instructional practices. (See Appendix 1)

The greater use of practical activities by users of **SciencePlus** can be explained as an effect of this curriculum. **SciencePlus** was designed to facilitate an increased use of

practical activities by teachers. The hands-on activities outlined in **SciencePlus** were developed taking into account the teachers' organizational problems (including low budgets for materials and supplies, infrequent access to a science laboratory and limited time for preparation). At the same time, eyes-on, hands-on, minds-on practical activity is integral to **SciencePlus**. Nearly every sequence of learning activities includes practical activity as an essential component of concept and skill development. The more frequent conduct of practical activities by teachers using **SciencePlus** compared to teachers not yet using this resource is probably evidence of the importance of suitable curriculum resources in facilitating practical activity in junior high science.

Association of the use of SciencePlus with a relative emphasis on testing for understanding rather than recall

The survey questionnaire asked teachers, "Which of the following best describes the extent to which you require recall of statements rather than application of understanding on your exams, tests and quizzes?" The options included:

A. All or nearly all my statements can be answered by recalling statements made in class or in the textbook
B. About 2/3 can be answered by recalling statements made in class or in the textbook
C. About half can be answered by recalling statements made in class or in the textbook
D. About 2/3 require students to apply their understanding to express their answers in their own words
E. All or nearly all require students to apply their understanding to express their answers in their own words

Table 2. Association of the use of SciencePlus with emphasis on testing for understanding

Emphasis in testing	Experience using the SciencePlus program					
	Never used	lst Year	2nd/3rd Year	4th + Year	Total row N	%
Recall	60.7	25.6	17.2	16.2	137	27.8
1/2 & 1/2	24.7	33.9	31.1	22.6	177	36.0
Understanding	14.6	39.5	41.8	42.3	178	36.2
Total column N	89	172	134	97	492	
%	18.1	35.0	27.2	19.7		100.0

Chi-square = 63.78030 (P = .0000)

Comments. Only 20% of **SciencePlus** users report testing mainly for recall, compared to 60% of non-users. This difference appears to reflect a change in student assessment practices that takes place during the first two years of using **SciencePlus.**

An explanation for the change can be found in the materials themselves. The **Teacher's Resource Books** to **SciencePlus** provide a model for developing test items and sample test questions which emphasize opportunities for students to express their understanding of the concepts and theories studied. This support for an emphasis on testing for understanding matches the emphasis in the student textbooks. These latter provide abundant opportunities for students to formulate, amend and reformulate their understanding of the concepts and theories encountered through a variety of forms of inquiry (including historical and practical explorations).

One initial indication of the impact on student learning of the **SciencePlus** approach may have been given by the Second International Science Study. This study included testing of Canadian students in May, 1984. Crocker (1989, p.47) reported in relation to the grade 9 scores that "Nova Scotia departs from the general pattern of lower scores for the Eastern provinces. Indeed, Nova Scotia ranks with Alberta in having the highest achievement at this level." In relation to Nova Scotia's results for grade 5 and grade 12, the standing of its grade 9 students is anomalously high.

The time of the testing of Canadian students, May 1984, predates by two years the publication and introduction into Nova Scotia grade 7 classes of **SciencePlus 1** and by four years the use by grade 9 students of **SciencePlus 3.** Nevertheless, approximately one quarter of the junior high science teachers in Nova Scotia at that time (although less than 10% in New Brunswick) are believed to have been involved in the development and use of early materials, primarily resource materials for teachers. This activity might account in part for the relatively high standing of Nova Scotia students on the international test. The more recent introduction of **SciencePlus** into most classrooms, including text resources for both student and teacher, appears from the results of this study to have had a significant impact on teaching practices. This in turn might reasonably be expected to have a further impact on student learning.

Association of participation in professional development activities with instructional practices

The survey questionnaire asked teachers: "During the last three years, how many provincial, national or international conferences or workshops concerned with science teaching did you attend?"

The results presented in Tables 3 and 4 confirm a previous finding of Yager, Hidayat and Penick (1988) that participation in professional development activities is positively associated with desired teaching practices. This does not prove that such attendance necessarily leads to changes in teaching practices, but on logical grounds it can be argued that opportunities to share teaching ideas with one's colleagues should have an effect on teaching practice.

Table 3. Association between attendance at professional conferences in science education with the conduct of hands-on practical activities

Average frequency of hands-on activities	Attendance at professional conferences (number in the past 3 years)				
	None	1 or 2	3 or more	Total row N	%
Twice monthly or less	63.3	50.3	32.9	249	50.6
Once per week	19.6	24.2	30.0	118	24.0
Twice per week	10.6	21.6	18.6	80	16.3
More than twice per week	6.5	3.9	18.6	45	9.1
Total column N	199	153	140	492	
%	40.4	31.1	28.5		100.0

Chi-square = 45.52876 (P = .0000)

Table 4. Association of attendance at professional conferences with emphasis on testing for understanding

Emphasis in testing	Attendance at professional conferences (number in the past three years)				
	None	1 or 2	3 or more	Total row N	%
Recall	35.7	28.1	17.1	138	28.0
1/2 & 1/2	37.2	33.3	37.1	177	36.0
Understanding	27.1	38.6	45.7	177	36.0
Total column N	199	153	140	492	
%	40.4	31.1	28.5		100.0

Chi-square = 18.79558 (P = .0009)

Comments. The results summarized in Tables 3 and 4 clearly favour the involvement of science teachers in science education conferences. A factor limiting this involvement, however, is the assignment to science teaching of teachers who have a stronger affiliation to another subject area. In Nova Scotia and New Brunswick, teachers have one opportunity each year to attend conferences organized by their subject-area professional associations. Regrettably, since the different subject-area associations meet on the same days, teachers must not only decide whether to attend, but must choose between subject areas.

Association between teaching assignment and instructional practices

The survey questionnaire asked teachers, "Which statement most clearly describes your teaching situation?" The options given were:

A. I teach only junior high science
B. I teach only science, including junior and senior high classes
C. At least half of my teaching is science, but I also teach another subject or subjects
D. Less than half of my teaching is science, but it is the subject area I teach most
E. I teach more in another subject area or areas than I do science.

Table 5. Association of teaching assignment with the conduct of hands-on practical activities

Average frequency of hands-on	Teaching assignment (proportion that is science)				
	Only science	Mainly science	Less than half science	Total row N	%
Twice monthly or less	31.5	49.7	62.8	248	50.3
Once per week	28.3	25.1	20.6	119	24.1
Twice per week	23.6	17.4	10.6	80	16.2
More than twice per week	16.5	7.8	6.0	46	9.3
Total column N	127	167	199	493	
%	25.8	33.9	40.4		100.0

Chi-square = 35.34500 (P = .0000)

Comments. The planning and organization required to conduct practical activities in science is more likely to be done by teachers who teach only or mainly science. The strength of the association found between frequency of hands-on activity and teaching assignment should persuade school principals to attempt to reduce the proportion of teachers who have science as a minor component of their teaching. Ideally, all science teaching should be done by teachers for whom science is their major teaching assignment.

Table 6. Association of teaching assignment with emphasis on testing for understanding

Emphasis in testing	Teaching assignment			
	Only science	Mainly science	Less than half science	Total row N %
Recall	29.1	17.4	36.2	138 28.0
1/2 & 1/2	39.4	32.3	36.2	176 35.7
Understanding	31.5	50.3	27.6	179 36.3
Total column N	127	167	199	493
%	25.8	33.9	40.4	100.0

Chi-square = 26.51893 (P = .0000)

Comments. The association between teaching assignment and testing emphasis favours those who teach mainly, but not only science. Apparently those teachers who teach other subjects as a minor component of their teaching assignment are more likely to test for understanding. This result may reflect the interdisciplinary character of teaching which emphasizes understanding. Those who teach only science are perhaps more likely to reflect a tradition in science teaching of so-called "objective" testing, including a reluctance to evaluate student verbal responses.

Association between location of teaching and instructional practices

The survey questionnaire asked teachers to estimate the proportion of science teaching they do in a classroom (defined as a location without all of the following: flat-top desks or benches, running water, fire extinguisher, readily accessible storage space), a lab-classroom (a location with the features listed above but where non-laboratory teaching is also ordinarily done), a laboratory, outside the school and other school locations. Tables

7 and 8 compare instructional practices of those teachers who do 80% or more of their science teaching in regular classrooms with those who do less than 80% of their science teaching in such classrooms.

Table 7. Association of the location of science teaching with the conduct of hands-on practical activity

Average frequency of hands-on activities	Location of science teaching			
	Less than 80% in regular class	80% + of time in regular class	Total row N	%
Twice monthly or less	40.2	69.4	256	51.0
Once per week	29.1	15.1	120	23.9
Twice per week	19.9	9.1	80	15.9
More than twice per week	10.8	6.5	46	9.2
Total column N	316	186	502	
%	62.9	37.1		100.0

Chi-square = 40.14777 (P = .0000)

Comments. The location of science teaching is clearly an important factor in relation to the conduct of practical activity. Teachers who have been able to gain access to a laboratory, lab-classroom or other suitable location for less than 20% of teaching time report conducting practical activity much less frequently than those who have such access.

Curricula like **SciencePlus** should be taught in a location in which whole-class interactive teaching, small group collaboration, individual student work and hands-on practical activity can be conducted interchangeably. Regular classrooms with movable tables and chairs are suitable for most of these modes of teaching/learning, but storage space, running water and a fire extinguisher are also minimum requirements for practical activity.

If SciencePlus is indeed a forerunner of the science curricula anticipated for the 90's, as Yager (1990) and Fensham (1991) have suggested, then there will need to be a reconceptualization of where science should be taught. A separate location in the school for conducting practical activities is an impractical arrangement for teaching which includes frequent student hands-on practical activity as part of a continuous process of facilitating conceptual change.

Table 8. Association of location of teaching with emphasis on testing for understanding

Emphasis in testing	Location of science teaching			
	Less than 80% in regular class	80% + of time in regular class	Total row N	%
Recall	22.8	39.2	145	28.9
1/2 & 1/2	37.3	31.7	177	35.3
Understanding	39.9	29.0	180	35.9
Total column				
N	316	186	502	
%	62.9	37.1		100.0

Chi-square = 15.87268 (P = .0004)

Comments. If practical activities are an essential part of a teaching strategy to facilitate conceptual change, then teaching in locations more conducive to practical activity is likely to be associated with greater emphasis on testing for understanding, as revealed in Table 8. This conclusion follows logically from the assertion that teachers who have not adequately provided for conceptual change are more likely to want to test for recall.

Education in science and science teaching practices

In the questionnaire, teachers were asked about the extent of their formal education in each of biology, chemistry, geology, physics and technology. Of the 502 respondents, 117 reported having degrees in science or technology, 73 of these in biology. Another 56 teachers reported having five or more full courses in one of the sciences but not a science degree. Of these, 37 have this level of education in biology. Therefore, cross-tabulations between the extent of education in biology and instructional practices only slightly understates the association between education in any of the sciences and science teaching practices.

Table 9. Association of the number of university courses taken in biology with the conduct of hands-on practical activities

Average frequency of hands-on activities	Number of courses in biology				
	5 +	3 or 4	2 or less	Total row N	%
Twice monthly or less	31.8	57.1	56.3	256	51.0
Once per week	29.1	19.6	22.9	120	23.9
Twice per week	24.5	5.4	14.9	80	15.9
More than twice per week	14.5	17.9	6.0	46	9.2
Total column N	110	56	336	502	
%	21.9	11.2	66.9		100.0

Chi-square = 33.12798 (P = .0000)

Table 10. Association of the number of university courses taken in biology with emphasis on testing for understanding

Emphasis in testing	Number of courses in biology				
	5 +	3 or 4	2 or less	Total row N	%
Recall	21.8	42.9	28.9	145	28.9
1/2 & 1/2	32.7	21.4	38.4	177	35.3
Understanding	45.5	35.7	32.7	180	35.9
Total Column N	110	56	336	502	
%	21.9	11.2	66.9		100.0

Chi-square = 13.59829 (P = .0087)

Comments. A degree in biology or at least five full courses is strongly associated with frequent conduct of practical activities and an emphasis on testing for understanding. There do not however appear to be such benefits from a lesser amount of scientific education.

Number of subject preparations and teaching practices

Teachers were asked in the questionnaire, "How many different subjects do you have to prepare for?" Cross-tabulations between their responses to this question and to questions about their instructional practices reveal no statistically significant associations (Tables 11 and 12).

Table 11. Association of number of subject preparations and the conduct of hands-on practical activities

Average frequency of hands-on activities	Number of subject preparations				
	1 or 2	3 or 4	5 or more	Total row N	%
Twice monthly or less	41.7	53.8	56.7	256	51.0
Once per week	27.2	22.4	22.7	120	23.9
Twice per week	17.9	15.2	14.9	80	15.9
More than twice per week	13.2	8.6	5.7	46	9.2
Total column N	151	210	141	502	
%	30.1	41.8	28.1		100.0

Chi-square = 9.95886 (P = .1264)

Comments. There is a significant probability (12.6%) that the trend observed in the data is due to chance. A larger population would have to be surveyed to determine whether the effect of a large number of subject preparations is a real reduction in the frequency of conduct of practical activities. On logical grounds, this might be expected.

Table 12. Association of the number of subject preparations with emphasis on testing for understanding

Emphasis in testing	Number of subject preparations				
	1 or 2	3 or 4	5 or more	Total row N	%
Recall	24.5	28.6	34.0	145	28.9
1/2 & 1/2	35.1	37.6	31.9	177	35.3
Understanding	40.4	33.8	34.0	180	35.9
Total column N	151	210	141	502	
%	30.1	41.8	28.1		100.0

Chi-square = 4.33248 (P = .3629)

Class size and instructional practices

Teachers were asked, "What is the average number of students in your junior high science classes?" Cross-tabulations between their responses to this question and to questions about their instructional practices revealed no statistically significant associations (Tables 13 and 14).

Table 13. Association of class size with the conduct of hands-on practical activities

Average frequency of hands-on activities	Class size				
	Less than or = 24	25 - 27	28 or more	Total row N	%
Twice monthly or less	49.3	48.6	55.9	256	51.0
Once per week	23.5	27.9	20.7	120	23.9
Twice per week	18.0	13.6	15.2	80	15.9
More than 2/wk	9.2	10.0	8.9	46	9.2
Total column N	217	140	145	502	
%	43.2	27.9	28.9		100.0

Chi-square = 3.85354 (P = .6965)

Table 14. Association of class size with emphasis on testing for understanding

Emphasis in testing	Class size				
	Less than or = 24	25 - 27	28 or more	Total row N	%
Recall	31.3	23.6	30.3	145	28.9
1/2 & 1/2	32.7	36.4	37.9	177	35.3
Understanding	35.9	40.0	31.7	180	35.9
Column total N	217	140	145	502	
%	43.2	27.9	28.9		100.0

Chi-square = 4.0331 (P = .4015)

Conclusions

The use of the **SciencePlus** program, participation in professional conferences in science eduction, teaching in locations which accommodate practical activity, a teaching assignment that includes mainly science and five or more completed undergraduate courses in biology have all been found to be associated with higher frequency of conduct of hands-on practical activities and an emphasis on testing for understanding rather than recall. On the other hand, no statistically significant association was found between these teaching practices and the number of subjects a teacher must prepare for each week or average class size.

Promising avenues for improving science teaching appear to include (1) the use by teachers and students of curriculum resources which integrate the conduct of practical activity with assessed concept and skill development and take into account the organizational and practical problems faced by teachers when conducting practical activity and assessing student progress; (2) the organization and conduct of voluntary professional development activity that is meaningful, attractive and accessible to teachers; (3) the location of science teaching in lab-classrooms; (4) teaching assignments which include science as the major component of the teacher's load; (5) the recruitment into grade 7, 8 and 9 science teaching of graduates who have completed at least five full undergraduate courses in a field of science.

APPENDIX 1 A Comparison of Nova Scotia and New Brunswick Grade 7, 8 and 9 Science Teaching

Conditions found in this study to be associated with differences in instructional practices (other than the extent of use of **SciencePlus**) are essentially the same in Nova Scotia and New Brunswick, as can be judged by comparison of the tabulated data in ASCP Research Reports 2 and 3 (McFadden, 1990a, 1990b). On the other hand, differences in reported teaching practices between Nova Scotia and New Brunswick teachers can be fully explained as an effect of the use of **SciencePlus**.

For example, from Table 1 it can be seen that the distribution of responses into categories of increasing frequency of conduct of practical activities is for users of **SciencePlus**: 44.2%, 26.3%; 18.6% and 10.9%. From Table 22 of ASCP Research Report 2, the distribution for Nova Scotia teachers alone is: 44.4%, 25.3%, 18.8% and 11.6%. However, from Table 22 of ASCP Research Report 3, the distribution for New Brunswick teachers is: 54.5%, 24.8%, 13.9% and 6.9%, implying significant differences in teaching practices between New Brunswick and Nova Scotia science teachers. If the 81 New Brunswick non-users become users of **SciencePlus** and this causes them to change their present teaching practices so that they become identical to the present users, the distribution for New Brunswick would be: 41.6%, 28.7%, 19.3% and 10.4%, reflecting an almost identical teaching practice to that in Nova Scotia. It appears,

therefore, to be easier to explain present differences in teaching practices as resulting from the use or non-use of **SciencePlus** than to predict and explain how otherwise similar groups of teachers would continue to differ in their teaching practices as much as they did at the time of the survey (May 1990).

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